Task Title: **SOOT AND CONTRAILS NEAR THE TROPOPAUSE - Grant No. NAG 2-923**

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Research Objectives

This project is aimed at developing, constructing and deploying instruments on the NASA DC-8 to characterize contrails and their environment. These will be utilized in the SUCCESS mission in April 1996. The overall purpose of this instrumentation is to characterize aircraft exhaust aerosol in terms of its ability to form solution droplets; their subsequent dilution and freezing; growth from the vapor as they disperse into their surroundings and their ultimate evaporation. The observations will be used to predict contrail behavior, its radiative properties in visible and thermal infrared and its potential for absorbed heterogeneous chemistry. Results are being compared with nucleation studies in the laboratories, and radiative properties of simulated ice clouds being obtained in a separate study.

Summary of Progress and Results - 1995

- The aerosol is to be characterized in terms of its total concentration (CN) and its cloud forming ability (CCN); this uses a standard TSI CN counter and a specific instrument for determining the CCN spectrum number as a function of supersaturation. The aerosol can be heated to 800°C which enables classification in terms of likely chemical constituents (sulfuric acid 120°C; ammonium sulfate/bisulfate 220°C). The output is a particle spectrum related to supersaturation and process temperature. Preliminary results with JP4 smoke show a significant reduction of the particles acting as CCN following heating above 200°C, suggesting the presence of sulfuric acid particles.
- Large aerosol particles (> few μm) and small (< few 100 μm) ice crystals are characterized by a cloudscope. This is a system which collects particles on an optical flat, tracing the airstream at a stagnation point, where evaporation occurs. Any non volatile component remain after evaporation. The output is a video image of particles giving location, size spectra, shape and density. Evaporation conditions are inferred from a computed stagnation environment. More specific and higher resolution information is obtained from a formvar replicator which covers the same size range, but provides a permanent records of particles (formvar casts) which can be examined by optical and scanning electron microscopy. The output is of detailed particle shapes, crystal morphology, and concentration.
- Work so far has involved restructuring the CCN spectrometer for mounting on the DC-8, providing the rack and stress analysis according to NASA specification. This has involved replacing pumps and motors and modifying the 60hz power panel. The instrument has been given an extended range to about 5% supersaturation. This has been found in laboratory tests on JP-4 smoke to increase the number of particles active as CCN, from a few % to about 20%. In parallel with this study we examined the CCN activity of different aircraft fuels, particularly the low sulfur variety, which initial results showed to give lower concentrations compared with higher sulfur fuel. A small burn facility has been constructed to give uniform combustion conditions for such smoke, using either a hot plate drop combustion system, or combustion over a heated water surface in a crucible.

- Test flights for the cloudscope and replicator were carried out on the DC-8 in August and September from NASA Ames. Each instrument fitted an optical probe housing. The first flights were at mid levels (-20°C) the second flight at high levels (41,000 ft, -58°C) in cirrus outflow from hurricane Juliette over the Pacific Ocean off Mexico.

Modifications to improve the optical system of the cloudscope (better illumination; sun glare elimination) and the formvar uniformity (reduce mechanical hysteresis in the formvar pump system) are being undertaken.

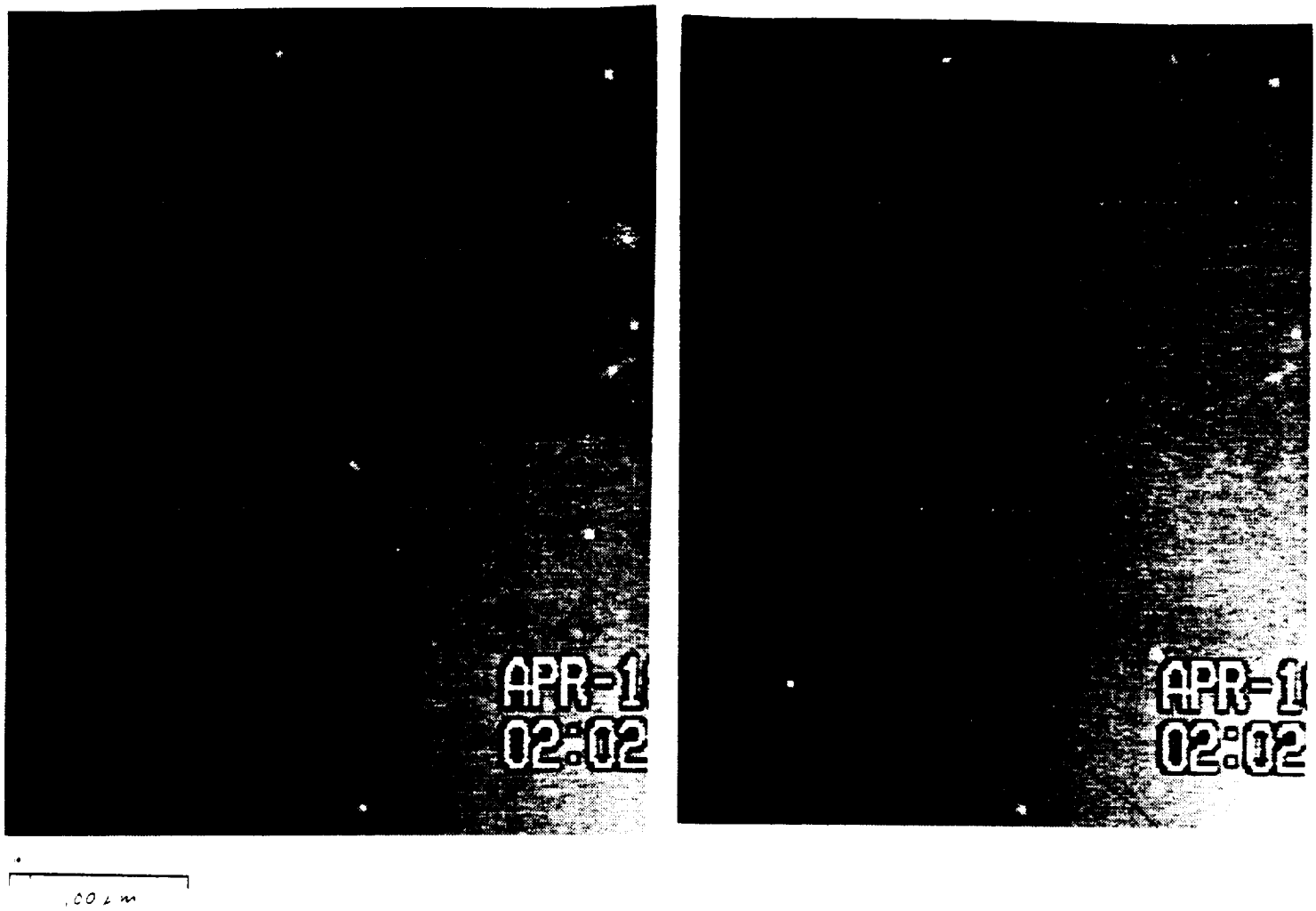

Figure: Cloudscope images from self penetration of a contrail by the University of the North Dakota Citation. This shows particle collection and evaporation over a period of about one second. Particle initial size is about 5 μm (total field of view is ½ mm x ½ mm.)

Accomplishments under present Grant No. NAG 2-923-**Year 1:**

1) Design and construction of Condensation Cloud Nuclei (CCN) spectrometer rack; provide stress analysis to NASA specifications. Replace pumps for aircraft specified design; modify 60 hz power panel.
2) Modify CCN spectrometer to work at higher supersaturations, above 5%.
3) Test flights in DC-8 of replicator and cloudscope August 1995, low level (-20C).
4) Test flights in DC-8 of replicator and cloudscope. September 1995 (Hurricane Juliette) high level (-60C).
5) Construction of a burn facility for laboratory tests on Cloud Condensation Nucleus/Condensation Nucleus ratio, related to volatility. Preliminary results for JP4; temperatures 100 to 500C; supersaturation up to 5%.

Plans for Year 2:

1) Modify cloudscope (in response to recent test flights) for optimum illumination to enable operation under conditions of higher ambient solar illumination and optimize recording system for aircraft operation.
2) Modify replicator (in response to recent test flights) to provide more uniform formvar coating.
3) Complete CCN and CN modifications, and install on DC-8; aerosol inlet design and installation (in association with NASA personnel).
4) Participate on test flights in DC-8 February 1996 as appropriate..
5) Participate in SUCCESS DC-8 flight April 1996.
6) Provide quality control of data during flights programs and "quick look" assessments of results.
7) Provide listing of data and quality assessment following flight program.
8) Begin detailed analysis of contrail data in terms of particle size distribution, mass spectra, CCN/CN ratio, related to volatility.
9) Begin detailed analysis of flight data comparing contrail influence on local ice evolution.
10) Complete laboratory test of CCN/CN ratio of selected fuels at controlled supersaturation.